WHAT IS CLAIMED IS:

1. An optical amplifier system having an input facet and an output facet, said system comprising:

a plurality of optical amplifiers arranged along an amplifier axis, each optical amplifier having a gain medium; and

a plurality of gain clampers disposed corresponding to said optical amplifiers to control the carrier density distribution of the gain medium of each optical amplifier, so that the whole carrier density distribution of the system is controlled.

2. The system as claimed in Claim 1, wherein said gain clamper varies the gain or loss coefficients of the gain medium of each optical amplifier.

3. The system as claimed in Claim 2, wherein said gain clamper uses electrodes biases to vary the gain or loss coefficients of the gain medium of each optical amplifier.

4. The system as claimed in Claim 2, wherein said gain clamper uses optical pumping to vary the gain or loss coefficients of the gain medium of each optical amplifier.

5. The system as claimed in Claim 2, wherein each of said gain clampers includes a gain-clamping laser cavity.

6. The system as claimed in Claim 1, wherein the whole carrier density distribution of the system is controlled at levels close to and just below the saturation-threshold-carrier-densities of the local photon densities along the amplifier axis.

7. The system as claimed in Claim 1, wherein said system is used as an optical signal equalizer to provide constant output power independent of input signal power level.

8. The system as claimed in Claim 1, wherein the whole carrier density distribution of the system declines from the input to the output.

9. An optical amplifier having an input facet and an output facet, said optical amplifier comprising:

a gain medium defining an amplifier axis; and

a plurality of gain clampers disposed along the amplifier axis to control the carrier density distribution.

10. The system as claimed in Claim 9, wherein said gain clamper varies the gain or loss coefficients of the gain medium of each optical amplifier.

11. The optical amplifier as claimed in Claim 10, wherein said gain clamper uses electrodes biases to vary the gain or loss coefficient of the gain medium of the optical amplifier.

12. The optical amplifier as claimed in Claim 10, wherein said gain clamper uses optical pumping to vary the gain or loss coefficient of the gain medium of the optical amplifier.

13. The optical amplifier as claimed in Claim 10, wherein each of said gain clamper includes a gain-clamping laser cavity.

14. The optical amplifier as claimed in Claim 13, wherein the laser cavities are arranged in an in-axis form along the amplifier axis.

15. The optical amplifier as claimed in Claim 14, wherein said laser cavities are implemented by a plurality of in-axis grating materials.

16. The optical amplifier as claimed in Claim 15, wherein said grating materials are disposed with the same pitch, and the more the grating material approaches the output facet end, the larger the index difference of the grating material is.

17. The optical amplifier as claimed in Claim 15, wherein said grating materials are disposed with the same pitch, and the more the grating material approaches the output

facet end, the larger the structure discontinuity of the grating material is.

18. The optical amplifier as claimed in Claim 15, wherein said grating materials have the same index difference and structure discontinuity, and are disposed with varying pitches so that the more the laser cavity approaches the output facet end, the more the oscillation wavelength of the laser cavities match the peak of the spectrum of the gain material.

19. The optical amplifier as claimed in Claim 18, wherein the pitch between the grating materials is decreased from the input facet end to the output facet end.

20. The optical amplifier as claimed in Claim 13, wherein said laser cavities are arranged in an off-axis form along the amplifier axis.

21. The optical amplifier as claimed in Claim 20, wherein each of said laser cavities is defined by a pair of laser mirrors disposed beside the gain medium and opposing to each other.

22. The optical amplifier as claimed in Claim 21, wherein said laser mirrors are wavelength non-selective mirrors, and the products of reflections of the mirror pairs increase toward the output facet end.

23. The optical amplifier as claimed in Claim 22, further comprising blocking spacers disposed between the laser cavities to separate the laser cavities from each other.

24. The optical amplifier as claimed in Claim 21, wherein said laser mirrors are wavelength selective mirrors, and the closer the laser mirror pair approach the output facet end, the more the reflection wavelength product of said laser mirror pair match the peak wavelength of the amplifier gain spectrum.

25. The optical amplifier as claimed in Claim 24, further comprising blocking spacers disposed between the laser cavities to separate the laser cavities from each other.

26. The optical amplifier as claimed in Claim 21, wherein said laser mirrors have the same reflectivity, and the more the laser mirror approaches the output end, the larger mirror area the laser mirror has.

27. The optical amplifier as claimed in Claim 26, further comprising blocking spacers disposed between the laser cavities to separate the laser cavities from each other.

28. The optical amplifier as claimed in Claim 21, further comprising loss wings disposed between each laser mirror and the gain medium, respectively.

29 The optical amplifier as claimed in Claim 28, wherein said laser mirrors have the same reflection and same area, the more the loss wing approaches the input facet end, the larger loss the loss wing has.

30. The optical amplifier as claimed in Claim 29, further comprising blocking spacers disposed between the laser cavities to separate the laser cavities from each other.

31. The optical amplifier as claimed in Claim 21, further comprising gain wings disposed between each laser mirror and the gain medium, respectively.

32. The optical amplifier as claimed in Claim 31, wherein said laser mirrors have the same reflection and same area, the more the gain wing approaches the output facet end, the larger gain the gain wing has.

33. The optical amplifier as claimed in Claim 32, further comprising blocking spacers disposed between the laser cavities to separate the laser cavities from each other.

34. The optical amplifier as claimed in Claim 20, wherein the laser cavities including a series of large laser cavities with gain or loss wings inserted therein to adjust the local carrier densities, and a series of narrow laser cavities to decide the carrier response time.

35. The optical amplifier as claimed in Claim 20, further comprising detectors for receiving optical powers from said laser cavities to output photo currents indicating signal power levels at the corresponding portions of the gain medium.

36. The optical amplifier as claimed in Claim 35, further comprising amplifiers for amplifier the optical powers from said laser cavities and transmitting the amplified optical powers to said detectors.

37. The optical amplifier as claimed in Claim 35, wherein said gain medium has at least one electrode being controlled by external signals to adjust the carrier densities of the gain medium.

38. The optical amplifier as claimed in Claim 37, wherein the external signals are generated by control circuits.

39. The optical amplifier as claimed in Claim 38, wherein the control circuits adjust the external signals by using the information carried by the photo currents from the detectors.

40. The optical amplifier as claimed in Claim 35, further comprising gain or loss wings inserted in the laser cavities, and the gain or loss coefficients of said gain or loss wings are controlled by control circuits.

41. The optical amplifier as claimed in Claim 40, wherein the control circuits control the gain or loss coefficients by using the information carried by the photo currents from the detectors.

42. The optical amplifier as claimed in Claim 9, wherein the carrier density distribution is controlled at levels close to and just below the saturation-threshold-carrier-densities of the local photon densities along the amplifier axis.

43. The optical amplifier as claimed in Claim 9, wherein said optical amplifier is used as an optical signal equalizer to provide constant output power independent of input signal power level.

44. The optical amplifier as claimed in Claim 9, wherein the carrier density distribution declines from the input to the output.

45. A semiconductor optical amplifier comprising:

a gain medium having input and output facets;

a slab waveguide region sandwiching said gain medium;

a grating structure placed above or below said slab waveguide region for defining laser cavities;

a spacing region provided between said slab waveguide region and the grating structure;

electronic contacts placed on and under the semiconductor optical amplifier for directing pumping currents into the semiconductor optical amplifier; and

a wafer base for supporting the respective components,

wherein the carrier density distribution of the gain medium is controlled by the difference between the local resonate frequency of the cavity and the peak frequency of the gain medium, and the less the difference is, the larger the carrier density is.

46. The semiconductor optical amplifier as claimed in 45, wherein the grating structure is constructed so that the local resonate frequencies of the cavities gradually approach to the peak frequency of the gain medium toward the output facet end.

47. The semiconductor optical amplifier as claimed in Claim 45, wherein the grating pitches of the grating structure are varied.

48. The semiconductor optical amplifier as claimed in Claim 47, wherein the varying grating pitches are achieved by arranging the gain medium, the slab waveguide region and the grating structure as curved profile.

49. The semiconductor optical amplifier as claimed in Claim 45, further comprising a plurality of bias electrodes disposed on the amplifier and along the amplifier axis to control the gain or loss coefficients of the gain medium.

50. The semiconductor optical amplifier as claimed in Claim 45, wherein the carrier density distribution is controlled at levels close to and just below the saturation-threshold-carrier-densities of the local photon densities along the amplifier axis.

51. The semiconductor optical amplifier as claimed in Claim 45, wherein said optical amplifier is used as an optical signal equalizer to provide constant output power independent of input signal power level.

52. The semiconductor optical amplifier as claimed in Claim 45, wherein the grating structure is constructed to have fixed grating pitch and accordingly fixed local resonate frequency, and the gain medium is constructed so that the peak frequencies of the gain medium vary along the amplifier axis.

53. A semiconductor optical amplifier comprising:

a gain medium having input and output facets;

a slab waveguide region sandwiching said gain medium;

a grating structure placed above or below said slab waveguide region for defining laser cavities;

a spacing region provided between said slab waveguide region and the grating structure;

electronic contacts placed on and under the semiconductor optical amplifier for directing pumping currents into the semiconductor optical amplifier; and

a wafer base for supporting the respective components,

wherein the carrier density distribution of the gain medium is controlled by the amplitude or discontinuity of the grating structure, and the larger the amplitude or discontinuity of the grating structure is, the smaller the carrier density is.

54. The semiconductor optical amplifier as claimed in Claim 53, further comprising a plurality of bias electrodes disposed on the amplifier and along the amplifier axis to

control the gain or loss coefficients of the gain medium.

55. The semiconductor optical amplifier as claimed in Claim 53, wherein the carrier density distribution is controlled at levels close to and just below the saturation-threshold-carrier-densities of the local photon densities along the amplifier axis.

56. The semiconductor optical amplifier as claimed in Claim 53, wherein said optical amplifier is used as an optical signal equalizer to provide constant output power independent of input signal power level.

57. The semiconductor optical amplifier as claimed in 53, wherein the grating structure is constructed so that the amplitude or discontinuity of the grating structure becomes gradually large toward the output facet end.

58. The semiconductor optical amplifier as claimed in Claim 57, wherein the grating pitches of the grating structure are uniform while the grating structure is getting closer to the slab waveguide region toward the output facet end.

59. A semiconductor optical amplifier comprising:

a gain medium having input and output facets;

a slab waveguide region sandwiching said gain medium;

distributed Bragg reflector (DBR) regions disposed beside the slab waveguide region for defining laser cavities;

electronic contacts placed on and under the semiconductor optical amplifier for directing pumping currents into the semiconductor optical amplifier; and

a wafer base for supporting the respective components,

wherein the carrier density distribution of the gain medium is controlled by the difference between the local resonate frequency of each cavity and the peak frequency of the gain medium, and the less the difference is, the larger the carrier density is.

60. The semiconductor optical amplifier as claimed in Claim 59, wherein the DBR

regions are arranged so that the local resonate frequency of the cavity gradually approaches to the peak frequency of the gain material toward the output facet end.

61. The semiconductor optical amplifier as claimed in Claim 59, wherein at least one DBR region has a thickness varying along the waveguide region.

62. The semiconductor optical amplifier as claimed in Claim 59, wherein at least one DBR region has a plurality of blocking regions formed therein to define the apertures of laser cavities, and the pitches between the blocking regions vary so that the apertures of laser cavities vary.

63. The semiconductor optical amplifier as claimed in Claim 59, further comprising a plurality of bias electrodes disposed on the amplifier and along the amplifier axis to control the gain or loss coefficients of the gain medium.

64. The semiconductor optical amplifier as claimed in Claim 59, wherein the carrier density distribution is controlled at levels close to and just below the saturation-threshold-carrier-densities of the local photon densities along the amplifier axis.

65. The semiconductor optical amplifier as claimed in Claim 59, wherein said optical amplifier is used as an optical signal equalizer to provide constant output power independent of input signal power level.

66. A semiconductor optical amplifier comprising:

a gain medium having input and output facets;

a slab waveguide region sandwiching said gain medium;

distributed Bragg reflector (DBR) regions disposed as pairs beside the slab waveguide region for defining laser cavities;

electronic contacts placed on and under the semiconductor optical amplifier for directing pumping currents into the semiconductor optical amplifier; and

a wafer base for supporting the respective components,

wherein the carrier density distribution of the gain medium is controlled by the product of reflectivity of the DBR region pair, and the larger the product is, the smaller the carrier density is.

67. The semiconductor optical amplifier as claimed in Claim 66, further comprising a plurality of bias electrodes disposed on the amplifier and along the amplifier axis to control the gain or loss coefficients of the gain medium.

68. The semiconductor optical amplifier as claimed in Claim 66, wherein the carrier density distribution is controlled at levels close to and just below the saturation-threshold- carrier-densities of the local photon densities along the amplifier axis.

69. The semiconductor optical amplifier as claimed in Claim 66, wherein said optical amplifier is used as an optical signal equalizer to provide constant output power independent of input signal power level.

70. The semiconductor optical amplifier as claimed in Claim 66, wherein at least one DBR region has the number of the DBR layers varying along the waveguide region.

71. The semiconductor optical amplifier as claimed in Claim 66, wherein at least one DBR region has a thickness varying along the waveguide region.

72. A semiconductor optical amplifier comprising:

a gain medium having input and output facets;

a slab waveguide region disposed along said gain material;

a plurality pairs of cross-cavity gain-clamping lasers, each cross-cavity gain-clamping laser comprising a wing bias electrode so that the gain or loss coefficient of the cross-cavity gain-clamping laser is controlled by biasing the wing bias electrode;

electronic contacts placed on and under the semiconductor optical amplifier for directing pumping currents into the semiconductor optical amplifier; and

a wafer base for supporting the respective components,

wherein the cross-cavity gain-clamping lasers are controlled so that the local resonate frequency of the gain material gradually approaches to the peak frequency of the gain material toward the output facet end

73. The semiconductor optical amplifier as claimed in Claim 72, further comprising surface emission lasers disposed along the slab waveguide region, the surface emission lasers defining narrow cavities to provide fast response time.

74. The semiconductor optical amplifier as claimed in Claim 73, wherein said surface emission lasers are implemented by DBRs.

75. The semiconductor optical amplifier as claimed in Claim 72, further comprising detectors for receiving optical powers from said laser cavities to output photo currents indicating signal power levels at the corresponding portions of the gain medium.

76. The semiconductor optical amplifier as claimed in Claim 75, further comprising amplifiers for amplifying the optical powers from said laser cavities and transmitting the amplified optical powers to said detectors.

77. The semiconductor optical amplifier as claimed in Claim 75, wherein the photo currents are used to control the bias for the wing electrodes to adjust the clamping of the carrier densities.

78. The semiconductor optical amplifier as claimed in Claim 72, wherein the cross-cavity gain-clamping lasers include at least one series of pairs of off-axis disposed cross-cavity gain-clamping lasers, each off-axis disposed cross-cavity gain-clamping laser comprising a gain wing having a gain material and mirror pairs to control the carrier density distribution of the amplifier.

79. The semiconductor optical amplifier as claimed in Claim 72, wherein the cross-cavity gain-clamping lasers include at least one series of pairs of off-axis disposed cross-cavity gain-clamping lasers, each off-axis disposed cross-cavity

gain-clamping laser comprising a loss wing having a loss material and mirror pairs to control the carrier density distribution of the amplifier.